



Prepared Expressly For:



Technical Memorandum

*Summary of Deepwater Horizon Trustees NRDA
Nearshore Tissue tPAH Concentrations*

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• **Deepwater Horizon Oil Spill** •

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TECHNICAL MEMORANDUM

SUBJECT: Summary of DWH Trustee NRDA Nearshore Tissue tPAH Concentrations

DATE: September 4, 2015

TO: Marla Steinhoff, NOAA; Mary Baker, NOAA

FROM: Jacob Oehrig, NewFields; Shahrokh Rouhani, NewFields; Mengni Zhang, NewFields

1.1 Introduction

This technical memorandum summarizes the available polycyclic aromatic hydrocarbon (PAH) concentration data collected from tissue samples within the nearshore environment of the northern Gulf of Mexico (GOM), as part of the Natural Resource Damage Assessment (NRDA) sampling efforts conducted by Trustees following the *Deepwater Horizon* (DWH) oil spill. In order to accommodate samples from submerged aquatic vegetation (SAV) and oyster beds, the “nearshore environment” is defined in this work as areas within 2,000 meters (m) of the shore.

All data discussed herein were acquired from Data Integration Visualization Exploration and Reporting (DIVER), a web-based resource maintained by the National Oceanic and Atmospheric Administration (NOAA), which houses a vast range of data associated with the DWH spill. Total PAH (tPAH) concentrations summarized in this memorandum are based on the DIVER toxPAH50 calculation option for tPAH data reporting.

1.2 Tissue Chemistry Data

As part of the DWH trustee NRDA sampling efforts, over 1,600 tissue samples were collected in the nearshore environment and analyzed for tPAH.¹ These samples were collected during 29 unique sampling efforts under five major workgroups, as shown in Table 1. Table 2 enumerates the tissue samples by species and oiling exposure category² of the shoreline closest to each tissue sample location. The compiled tissue tPAH data cover locations from the coast of Texas to the western coast of Florida, as shown in Figure 1. In addition, over 1,800 historical tissue samples, collected between 1988 and 2009 in the northern GOM nearshore environment and compiled in DIVER, were used to compare pre-spill conditions.

¹ Tissue samples were routinely rinsed prior to laboratory analysis. The rinsate material was also collected and analyzed separately. DIVER refers to rinsate sample as “external material.” Other external materials include wipe samples and stranded oil found on investigated biota. This work does not include external material results.

² For vegetated shorelines, shoreline oiling exposure categories included heavier persistent oiling (where heavy or moderate oiling was repeatedly observed over a period of 12 weeks or longer), heavier oiling (where moderate or heavy oiling persisted for less than 12 weeks), lighter oiling (where only trace to light oiling was observed), no oil observed, and shoreline not surveyed (Nixon *et al.*, 2015).

Table 1. Summary Counts of Nearshore Biota Tissue Chemistry Samples with tPAH results by Workgroup

Workgroup	Total Number of Samples
Oyster	614
SAV Marine Mammals and Turtles	426
Marine Mammals and Turtles	419
Fish	174
Other Tasking Agency	4
Total	1,637

Table 2. Summary Counts of Nearshore Biota Tissue Chemistry Samples with tPAH results by Shoreline Oiling Category

Class	Species Group	Shoreline Oiling Exposure Category					
		Heavier Persistent Oiling	Heavier Oiling	Lighter Oiling	No Oil Observed	Not Surveyed	Total
Animals unknown		1	5	23	3	6	38
Bivalves and Clams	Bivalvia unknown	1	4	1	1	3	10
	Eastern oysters	16	21	84	294	204	619
	Donax	1	20	7	3	-	31
Cartilaginous fish/ Rays/Sharks	Atlantic stingray	-	-	-	1	2	3
Gastropods/Slugs/ Snails	Gastropoda unknown	-	1	8	4	-	13
Magnoliopsida	Alismatales unknown	1	13	64	37	22	137
	Manatee grass/ Manatee-grass	-	-	4	-	1	5
	Shoalweed	-	4	32	4	13	53
	Turtlegrass	-	3	2	11	13	29
	Widgeongrass	-	2	1	1	6	10
Malacostraca	Atlantic seabob	-	-	1	-	-	1
	Blue crab	30	83	30	10	6	159
	Brown shrimp/ Golden shrimp/ Northern brown shrimp/ Red shrimp/ Redtail shrimp	-	1	8	-	1	10
	Decapoda unknown	-	13	35	3	14	65
	Northern white shrimp/ White shrimp	-	-	3	10	4	17
	Penaeidae shrimp	7	14	14	29	8	72
	Thinstripe hermit	-	1	-	-	1	2
	Atlantic Spotted Dolphin	-	2	-	-	-	2
Mammals	Bottlenose Dolphin	11	38	29	47	22	147
	Spinner Dolphin	-	-	2	-	-	2
Not Defined		-	4	9	15	31	59

Class	Species Group	Shoreline Oiling Exposure Category					
		Heavier Persistent Oiling	Heavier Oiling	Lighter Oiling	No Oil Observed	Not Surveyed	Total
Paddle-footed annelids/ Polychaetes		-	2	1	-	-	3
Ray-finned fish/ Spiny rayed fishes	Ariidae unknown	-	-	-	-	5	5
	Black mullet/ Gray mullet/ Striped mullet	1	1	-	-	-	2
	Cynoscion unknown	-	-	-	-	1	1
	Gulf killifish	3	-	-	-	-	3
	Gulf menhaden/ Largescale menhaden	-	-	-	1	3	4
	Hardhead Catfish	-	-	-	-	1	1
	Pinfish	-	-	1	-	1	2
	Red Drum	1	-	-	-	-	1
	Sciaenidae unknown	5	3	-	-	-	8
	Sheepshead	-	1	-	-	-	1
	Star drum	-	-	2	-	-	2
Reptiles	Atlantic Ridley Sea Turtle	-	14	49	20	13	96
	Green Sea Turtle	-	-	2	-	-	2
	Loggerhead Sea Turtle	2	7	2	-	11	22
Total		80	257	414	494	392	1,637

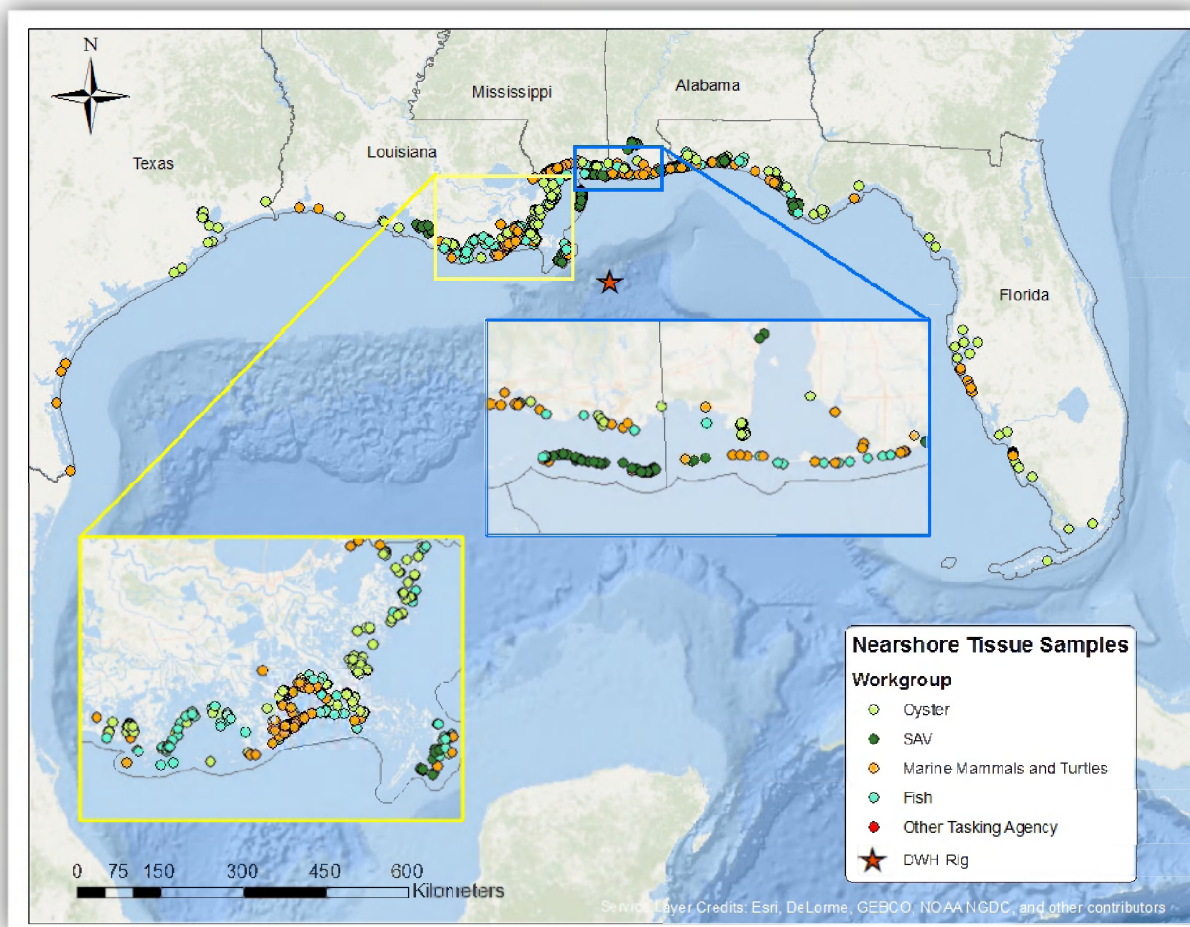


Figure 1. Nearshore Tissue Chemistry Sampling Locations

1.3 DIVER tissue PAH Concentrations

This section focuses on DWH trustee NRDA tissue samples collected in 2010, 2011, and 2012. Summary statistics of post-2010 tissue tPAH concentrations, including count, minimum, maximum, average, and standard deviation, are listed in Table 3.

Table 3. Summary statistics of post-2010 Tissue tPAH concentrations by Species

Class	Species Group	Material	Count	Minimum	Maximum	Average	Standard Deviation
Animals unknown		Whole body	38	0.2	640.5	46.6	140.1
Bivalves and Clams	Bivalvia unknown	Whole body	10	1.4	186.2	42.8	57.5
	Eastern oysters	Whole body	619	0	1,149.8	28	63
	Donax	Whole body	31	4.1	737.2	118.3	150.3
Cartilaginous fish/ Rays/Sharks	Atlantic stingray	Gills	2	7.6	28	17.8	14.4
		Whole body	1	23.9	23.9	23.9	NA
Gastropods/ Slugs/Snails	Gastropoda unknown	Whole body	13	7.8	514.3	89.1	165.4
Magnoliopsida	Alismatales unknown	Leaves and/or Stems	137	0.8	1,265.6	39.3	113.5
	Manatee grass/ Manatee-grass	Leaves and/or Stems	5	2.8	12.7	6.7	4.4
	Shoalweed	Leaves and/or Stems	53	0.4	9,400.1	192.9	1,289.2
	Turtlegrass	Leaves and/or Stems	29	0.6	30.7	10.7	7.6
	Widgeongrass	Leaves and/or Stems	10	0.6	90.7	28.4	35.7
Malacostraca	Atlantic scabob	Whole body	1	13.6	13.6	13.6	NA
		Claw	5	1.2	9.4	4.7	3.5
	Blue crab	Eggs	2	19	33.7	26.3	10.4
		Gills	14	0.2	140	32.7	46.3
		Gonad	3	19.8	58.3	36.3	19.8
		Hepatopancreas	11	0	178.7	36.3	67.4
		Muscle	12	0.1	13	5.7	4.1
		Shell	1	0.8	0.8	0.8	NA
		Whole body	111	0	554.4	42.5	95.4
	Brown shrimp/ Golden shrimp/ Northern brown shrimp/ Red shrimp/ Redtail shrimp	Whole body	10	1.1	55.9	13	19.2
	Decapoda unknown	Whole body	65	0	49,578.5	892.9	6,201.6
	Northern white shrimp/ White shrimp	Head and Shell	1	1.1	1.1	1.1	NA
		Whole body	16	3.9	36.2	10.8	8.1
	Penaeidae shrimp	Whole body	72	0.1	188.3	23.7	32.6
	Thinstripe hermit	Whole body	2	0	19.4	9.7	13.7
Mammals	Atlantic Spotted Dolphin	Lung	1	5.2	5.2	5.2	NA
		Liver	1	6.7	6.7	6.7	NA
	Bottlenose Dolphin	Liver	29	0.3	727	50.6	133.5
		Lung	36	0.6	306.3	17.5	50.4
		Plasma	47	0.4	8.0	3.7	1.8
		Skin and Blubber	12	31.9	270.1	166.6	88.1
		Stomach Contents	23	2	102.2	22.7	27.6
	Spinner Dolphin	Liver	1	8.5	8.5	8.5	NA
		Lung	1	4.4	4.4	4.4	NA

Class	Species Group	Material	Count	Minimum	Maximum	Average	Standard Deviation
Not Defined		Edible tissue	1	47.7	47.7	47.7	NA
		Leaves and/or Stems	13	12.7	107.6	35.7	26.2
		Not Defined	2	1,481.2	1,596	1,538.6	81.2
		Whole body	43	0	1,028.7	45.8	160.3
Paddle-footed annelids/Polychaetes		Whole body	3	13.9	51.2	33.2	18.7
Ray-finned fish/ Spiny rayed fishes	Ariidae unknown	Gills	2	33.2	86.8	60	37.9
		Whole body	3	20	42	33	11.5
	Black mullet/ Gray mullet/ Striped mullet	Whole body	2	29.2	149.5	89.4	85
	Cynoscion unknown	Gills	1	119.6	119.6	119.6	NA
	Gulf killifish	Whole body	3	1.8	17.2	7.4	8.5
	Gulf menhaden/ Largescale menhaden	Whole body	4	20.1	70	50.9	22
	Hardhead Catfish	Whole body	1	72.3	72.3	72.3	NA
	Pinfish	Whole body	2	3.9	47.5	25.7	30.9
	Red Drum	Whole body	1	5.2	5.2	5.2	NA
	Sciaenidae unknown	Whole body	8	2.7	111.8	32.3	36.6
	Sheepshead	Whole body	1	14	14	14	NA
	Star Drum	Whole body	2	4.4	6.3	5.4	1.3
Reptiles	Atlantic Ridley Sea Turtle	Colon Contents	18	0.2	42.2	15.9	12.6
		Liver	48	0.3	373.6	18.9	53
		Lung	6	0	1.8	0.5	0.7
		Mixed Tissue	23	0.4	312,072	17,030.6	65,918
		Stomach Contents	1	5.9	5.9	5.9	NA
	Green Sea Turtle	Liver	1	3.4	3.4	3.4	NA
		Mixed Tissue	1	35.5	35.5	35.5	NA
	Loggerhead Sea Turtle	Colon Contents	4	1.4	7.9	4.7	3.2
		Eggs	13	0	28.9	2.5	7.9
		Liver	5	0.8	13.6	7	5.6
Total Count			1,637				

1.4 Historical tPAH Comparison

As shown in Figure 2, only oyster tissues have historical and post-2010 PAH concentration datasets large enough for reliable statistical comparisons. However, these comparisons did not reveal any discernable increase in post-2010 tissue tPAH values (Table 4).

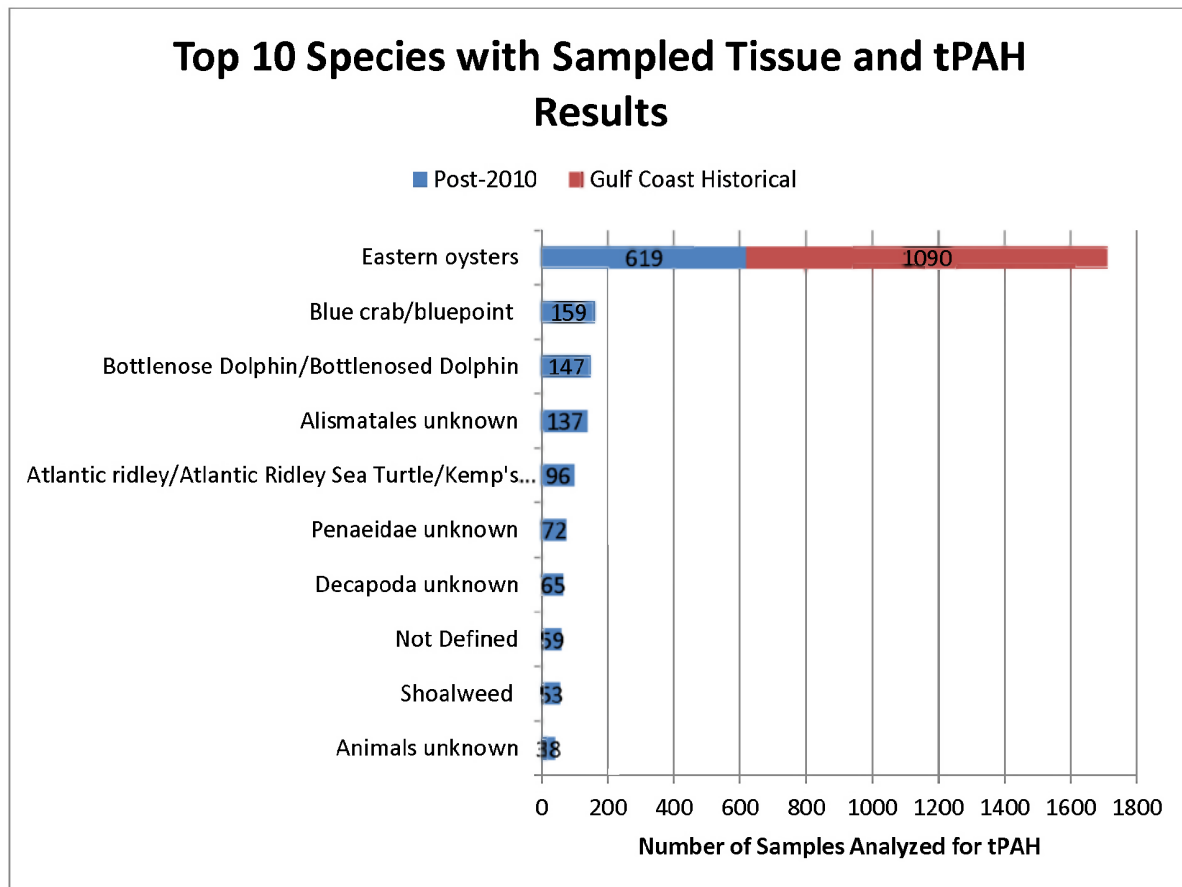


Figure 2. Post-2010 and corresponding Historical Tissue Chemistry Sample Availability

Table 4. Comparison of Summary Statistics of Historical and post-2010 Oyster Tissue tPAH Concentrations

Statistics	Historical Data (1988-2009)	Post-2010 Data (2010-2012)
Count	1,090	619
Minimum	0	0
Maximum	13,960	1,150
Median	47.0	13.4
Mean	197.1	28.0
Std. Deviation	780.5	63.0
t-Test	p<0.001; Historical mean is significantly higher than post-DWH-spill mean at a 5% level.	
Mann-Whitney U Test	p<0.001; Historical median is significantly higher than post-DWH-spill median at a 5% level	

Due to the limited availability of tissue tPAH data, no specific conclusion about tissue chemistry samples could be derived for this work.

1.5 Forensic Results

To quantitatively confirm the exposure of the nearshore environment to the oil from the DWH spill (Mississippi Canyon 252 or MC252 oil), over 800 tissue samples were subjected to forensic PAH and biomarker analyses, as described by Emsbo-Mattingly and Martin (2015). The hydrocarbon and biomarker patterns of selected tissue samples were evaluated for MC252 oil presence and categorized as either Code A (consistent with MC252 oil), Code B (probably oil with some background material present), Code C (possibly MC252 oil with mostly background material present), Code D (inconclusive), or Code E (consistent with non-MC252 oil) (Emsbo-Mattingly and Martin, 2015).

Summary counts and average tPAH concentrations of forensically analyzed tissue samples by species are displayed in Table 5. The average tPAH concentrations are provided in parentheses adjacent to the count. The geographic locations of these samples are depicted in Figure 3. In general, species-specific tissue sample tPAH concentrations associated with MC252 oil (Forensic code A or B) were higher than those with no MC252 oil association (Code D). However, sample sizes were too small for reliable statistical comparisons.

Table 5. Summary Counts and Average tPAH Concentrations of Forensically Analyzed Tissue Samples by Species (average tPAH concentrations in ppb are provided in parentheses adjacent to the count).

Class	Species Group	Tissue Type	Forensic Code					
			A	B	C	D	E	Total Count
Animals unknown		Whole body	-	1 (640)	-	24 (19)	-	25
Bivalves and Clams	Bivalvia unknown	Whole body	-	-	-	10 (43)	-	10
	Eastern oysters	Whole body	-	-	1 (88)	238 (31)	1 (154)	240
	Donax	Whole body	-	6 (206)	5 (102)	17 (57)	3 (316)	31
Cartilaginous fishes/ Rays/Sharks	Atlantic stingray	Gills	-	-	-	2 (18)	-	2
Gastropods/Slugs/ Snails	Gastropoda unknown	Whole body	-	-	-	13 (89)	-	13
Magnoliopsida	Alismatales unknown*	Leaves and/or Stems	1 (264)	-	3 (475)	121 (25)	-	125
	Manatee grass/ Manatee-grass	Leaves and/or Stems	-	-	-	5 (7)	-	5
	Shoalweed	Leaves and/or Stems	-	-	-	53 (193)	-	53
	Turtlegrass	Leaves and/or Stems	-	-	-	29 (11)	-	29
	Widgeongrass/ Widgeon-grass	Leaves and/or Stems	-	-	1 (91)	9 (22)	-	10
Malacostraca	Blue crab	Claw	-	-	-	5 (5)	-	5
		Eggs	-	-	-	2 (26)	-	2
		Gills	-	-	-	14 (33)	-	14
		Gonad	-	-	-	3 (36)	-	3
		Hepatopancreas	-	-	-	11 (36)	-	11
		Muscle	-	-	-	12 (6)	-	12
		Whole body	-	-	-	3 (14)	-	3
	Brown shrimp/ Golden shrimp/ Northern brown shrimp/ Red shrimp/ Redtail shrimp	Whole body	-	-	-	9 (12)	-	9
	Decapoda unknown	Whole body	3 (19,103)	1 (95)	2 (8)	59 (10)	-	65
	Penaeidae shrimp	Whole body	-	-	-	72 (24)	-	72
	Thinstripe hermit	Whole body	-	-	-	2 (10)	-	2
Not Defined		Edible tissue	-	-	-	1 (48)	-	1
		Leaves and/or Stems	-	-	-	13 (36)	-	13
		Not Defined	-	-	2 (1,539)	-	-	2
		Whole body	1 (1,029)	-	1 (216)	39 (18)	-	41
Paddle-footed annelids/Polychaetes		Whole body	-	-	-	3 (33)	-	3
Ray-finned fishes/ Spiny rayed fishes	Ariidac unknown	Gills	-	-	-	2 (60)	-	2
		Whole body	-	-	-	3 (33)	-	3
	Cynoscion unknown	Gills	-	-	-	1 (120)	-	1
	Gulf menhaden/ Largescale menhaden	Whole body	-	-	-	4 (51)	-	4
	Pinfish	Whole body	-	-	-	1 (48)	-	1
Total Count			5	8	15	780	4	812

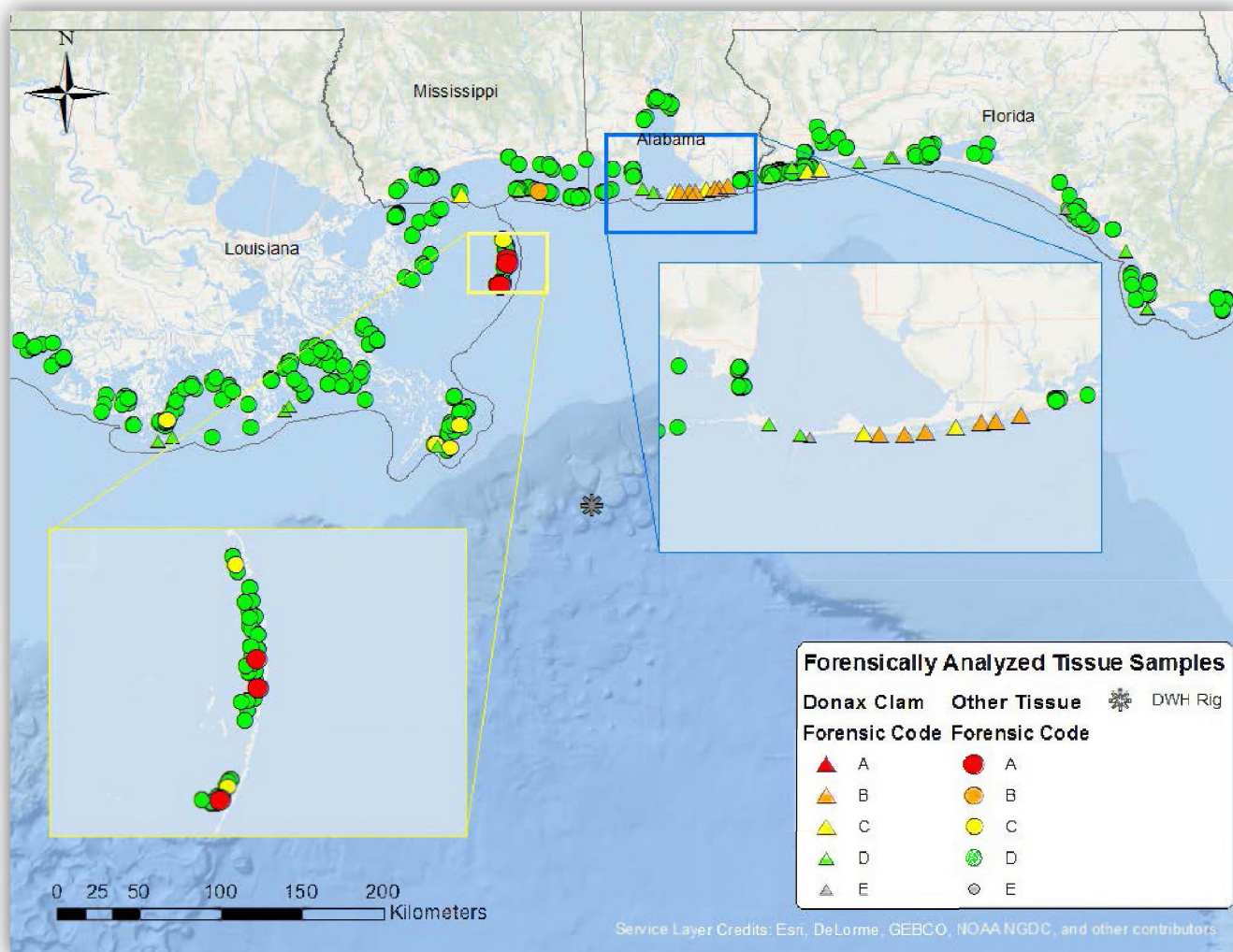


Figure 3. Tissue Sample Forensic Results

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- Nixon, Z.; Zengel, S.; Michel, J. 2015. Shoreline Oiling from the Deepwater Horizon Oil Spill.